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④ Accelerators for vulcanizing vinylidene fluoride elastomeric copolymers.

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Description

This invention relates to vulcanizable compositions based on elastomeric copolymers of vinylidene fluoride, to a process for vulcanizing such compounds and to the vulcanized compositions so obtained.

5 The vulcanized elastomers based on vinylidene fluoride copolymers are well known and are widely employed in a plurality of applicative fields where an exceptional chemical resistance to solvents, lubricants, fuels, acids and the like, even at very high temperatures, is required.

10 The vulcanized articles prepared from these elastomeric copolymers are most suitably utilized as sealing gaskets in general, in both static and dynamic conditions, in the motorized, aeronautical, missilistic, naval, mechanical, chemical sectors, in the protective impermeabilizations of various supports, as protective garments for the contact with aggressive chemical agents, as sheaths for electrical cables exposed to an intense thermal radiation and, finally, as protective linings of industrial containers.

15 According to the most advanced art, for the vulcanization of the vinylidene fluoride elastomeric copolymers use is made, as vulcanizing agents, of polynucleophilic compounds and in particular of aromatic polyhydroxyl compounds (or of similar thioderivatives), either as such or in the salified form.

These products lead, in fact to vulcanized articles endowed with fully satisfactory physical-mechanical and heat-resistance characteristics.

Such products, however, are affected by the drawback of requiring extremely long vulcanization times, wherefore they are employed in combination with substances exerting an accelerating action.

20 The accelerators according to the present invention are soluble in the same solvents of the fluoroelastomers, in particular acetone, dimethylformamide, dimethylsulphoxide (see Acta Chem. Scand. A 31 1977, page 647) and exhibit a high consistency with the fluoroelastomers. This fact permits a perfect homogenization in the blend, thus avoiding hypervulcanization phenomena or scorching, or undervulcanization phenomena, with consequent insufficient and non-homogeneous adhesion of the 25 vulcanized articles to metals.

Among the substances which exert an accelerating action according to the most advanced technique there are described derivatives of tertiary amines containing four nitrogen-carbon covalent bonds, and derivatives of tertiary phosphines containing four phosphorus-carbon covalent bonds (French patents No. 2,091,806 and No. 2,096,115).

30 Compounds containing one or more carbon-nitrogen covalent bonds (US Patent 4,259,463) and compounds having the structure of phosphonium ylides (US Patent 3,752,787) are described too.

It has been now surprisingly found that the compounds having structures of bis(triarylphosphin)-iminium salts (or PPN salts) of general formula



wherein Ar is an aryl radical, n=1 or 2, X is a monovalent or divalent anion, may be advantageously utilized as vulcanization accelerators for the fluoroelastomers. The positive charge of the cation can be assigned to the N atom, but it can be also equally distributed to two phosphorus atoms.

40 Such compounds are also referred to as (when Ar=phenyl) nitrido-bis(triphenylphosphine) salts [Z. Anorg. Allgem. Chem. 311 290 (1961)], while the name according to Chem. Abstr. results to be, e.g. for the compound with X=Cl and Ar=phenyl, the following: P,P,P-triphenyl-phosphin-imide N(chlorotriphenylphosphoranyl).

The preparation of salts of this class is broadly described by A. Martinsen and J. Sargstad in Acta 45 Chem. Scand. Sec. A. (1977) 645—650.

Thus, it is an object of the present invention to provide vulcanizable compositions based on elastomeric copolymers of vinylidene fluoride, containing polynucleophilic compounds as vulcanizing agents, which are not affected by the drawbacks mentioned hereinbefore.

Another object is that of providing a process for vulcanizing compositions based on vinylidene fluoride 50 elastomeric copolymers, which is free from the shortcomings cited hereinabove and is capable of providing vulcanized articles exhibiting a high adhesion to metal substrates.

A third object is also that of providing vulcanized compositions based on vinylidene fluoride elastomeric copolymers, free from the drawbacks mentioned in the foregoing, and which may be shaped by injection molding.

55 These and still further objects are achieved by compositions comprising:

- I) 100 parts by weight of a vinylidene fluoride elastomeric copolymer, with one or more fluorinated or chlorofluorinated ethylenically unsaturated monomers, such as e.g. 1-hydropentafluoropropene; 2-hydropentafluoropropene; 1,1-dihydrotetrafluoropropene, partially or thoroughly fluorinated alkyl- and arylvinylethers, and the like;
- II) 1—40 parts by weight of an inorganic acid acceptor, consisting of one or more basic oxides of divalent metals, selected from the group comprising magnesium oxide, calcium oxide, lead monoxide, zinc oxide and/or of one or more basic lead phosphites, optionally in the form of cationic complexes or chelates;

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- III) 0.5—10 parts by weight of one or more basic compounds, selected from the group comprising the calcium, strontium and barium hydrates, the metal salts of weak acids such as carbonates, benzoates and phosphates of calcium, strontium, barium, sodium and potassium, optionally in the form of complexes with the normal cationic chelating and complexing agents of the type well known to those skilled in the art;
- IV) 0.5—15 and preferably 1—6 parts by weight of a vulcanizing agent based on one or more polyhydroxyl and/or polythiol compounds of general formulas $A(BC)_n$, and/or $CH-R-BC$ in which A is an arylene radical, n is an integer equal to or higher than 2, B is oxygen or sulphur; C is hydrogen or an alkaline metal, R is an alkylene or cycloalkylene, mono- or polyalkylenecycloalkyl, or alkylenedaryl or oxoalkylenedaryl radical;
- V) 0.05—5 parts of a vulcanization accelerator as described hereinabove.

The vulcanizable compositions of the type specified hereinabove are vulcanized by means of a process, which too is an object of the present invention, that consists in first heating said compositions, under pressure, to temperatures in the range from 130°C to 230°C, preferably from 160°C to 200°C, during a time from 0.5 to 60 and preferably from 1 to 20 minutes; the articles so obtained are successively post-vulcanized in an oven or a furnace, at atmospheric pressure, at temperature ranging from 130°C to 315°C, preferably from 200°C to 275°C, for a period of time from 5 to 48 and preferably from 10 to 24 hours.

It has surprisingly been ascertained that the vulcanizable compositions according to this invention can be transformed into articles of any shape and size by extrusion molding and subsequent vulcanization, employing also highly automated injection technologies; in fact, at the high temperatures which are usual for the injection molding process, no drawbacks occur due to scorching or hot tearing phenomena.

Such articles exhibit an excellent resistance to permanent set and to compression, a minimum tendency to scorching as a function of the storing time and temperature or of the temperatures of particular processing technologies, such as for example the extrusion, and also a high resistance to thermal ageing; furthermore, they can be bonded to metal substrates of different types, to which they exhibit a considerable adhesion even at high temperatures.

It was also observed that the vulcanizable compositions, including the additives from I) to V) cited hereinbefore, do not give rise to tackiness or soiling phenomena of the molds, wherefore production rejections are practically absent, so allowing high production standards and highly regular processing cycles.

The process according to the present invention is particularly suitable in the case of copolymers containing from 30 to 70% by moles of vinylidene fluoride and from 70 to 30 % by moles of 1-hydropentafluoroprene and/or hexafluoropropene, or in the case of vinylidene fluoride/tetrafluoroethylene/hexafluoropropene and/or 1-hydropentafluoropropene terpolymers, in which the per cent amounts of the three monomers respectively range from 40 to 80, from 30 to 10 and from 30 to 10 % by moles.

More in general, the process according to the present invention is advantageously utilizable for all the fluorinated polymeric materials of the elastomeric type, optionally containing substituents other than fluorine and chlorine, and also for the mixtures of two or more fluorinated elastomers.

The polyhydroxyl or polythiol compounds to be used as vulcanizers conforming to this invention are those well known in the art. Particularly suitable are hydroquinones, resorcin, catechol, naphthols, polyhydroxybenzophenones, bisphenols and derivatives thereof containing in the aromatic ring and/or in the aliphatic group (R=alkylenedarylene group) substituents different from hydrogen and in particular halogens such as chlorine and fluorine, and corresponding thiol-derivatives, either as such or monosulfided, bisulfided or polysulfided with alkaline metals; lower aliphatic and cycloaliphatic diols, such as 1,4-butandiol; di-alkylenecycloaliphatic diols, such as 1,4-dihydroxymethyl-cyclohexane and dialkylenearomatic diols, such as 1,4(dihydroxymethyl)benzene and corresponding thiol-derivatives, either as such or mono- or bisulfided with alkaline metals.

Preferred compounds to be used according to the present invention as vulcanization accelerators are:

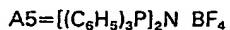
A1=[(C₆H₅)₃P]₂ NCl M.P.=260°C
Bis(triphenylphosphin)iminiumchloride

A2=[(C₆H₅)₃P]₂N NO₃ M.P.=227°C
Bis(triphenylphosphin)iminiumnitrate prepared according to the teachings of J. K. Ruff and W. J. Schlientz in "Inorganic Synthesis" vol. 15, 1974), page 85;

A3=[(C₆H₅)₃P]₂NBr M.P.=256°C
Bis(triphenylphosphin)iminiumbromide

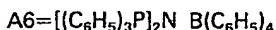
A4=[(C₆H₅)₃P]₂N I M.P.=254°C
Bis(triphenylphosphin)iminiumiodide the last two compounds having been prepared according to the method described by R. Appel and A. Hauss "Zeit. Anorg. Allg. Chem." 311, 290, (1961);

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Bis(triphenylphosphin)iminiumtetrafluoroborate; this compound is prepared from equimolar amounts of A1 and of sodium tetrafluoroborate in aqueous solution. The product precipitates in the form of very fine white crystals having a melting point of 233°C;

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Bis(triphenylphosphin)iminiumtetraphenylborate. It is prepared in like manner as the preceding product, but using an aqueous solution of potassium hexafluorophosphate; white crystals having a melting point of 216°C.

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The accelerator amount to be employed in the process according to the present invention, though remaining in the range allowed by the high solubility of the additive in the fluorinated elastomer, depends on whether or not steric hindrances are present in the additive, on the basicity degree of the vulcanizable composition and on many other factors connected with the other particular additives utilized, on the type, shape and dimension of the article to be manufactured, on the vulcanization conditions and on the heating system and modalities during vulcanization.

15.

The vulcanizable compositions according to the present invention may contain, in addition to the substances indicated hereinbefore from I) through V), carbon black, white and coloured fillers, plasticizers and lubricants already known, such as stearates, arylphosphates, polyethers, polyesters, polyethylene and other known additives, according to the techniques usually employed by the fluorinated elastomers users.

20.

The components of the vulcanizable compositions of the present invention are easy to incorporate into the vinylidene fluoride elastomeric copolymer, both separately and premixed, or they may be solubilized in solvents and then caused to be adsorbed on inert fillers having a large surface area, without giving rise to any undesired accompanying phenomenon, such as surface efflorescence, caused by migration phenomena inside the vulcanizable composition, due to the high compatibility with the elastomer.

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In this way it is possible to reach good vulcanization rates at the usual processing temperatures without encountering, however, any risk of scorchings (prevulcanization) in the preliminary processing steps prior to the actual vulcanization.

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Finally, another advantage according to the present invention consists in the complete elimination of the undesired "back rinding" phenomena during vulcanization in closed mold and under pressure of articles prepared from fluorinated elastomers, particularly in the case of O-ring gaskets.

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According to a preferred embodiment of the process according to the present invention, the mixture of bis(triarylphosphin)-iminium salt (0.1—2 parts by weight) and of vulcanizing agent (1—6 parts by weight) is added in the fluorinated elastomer (100 parts by weight), before adding the acid acceptor (2—10 parts by weight), with the basic compounds (1—7 parts by weight), the reinforcing and inert fillers, the lubricants, the plasticizers and other optional additives.

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By operating in this manner, a quick, controlled and uniform vulcanization is obtained, without any risk of undesired phenomena, such as scorchings during the various processing steps of the mix or during the storage thereof. Similarly, any risk of losses due to volatilization during preparation and storage of the vulcanizable compositions; furthermore, no special measures are to be taken by the personnel in charge of the processing steps, thanks to the high consistency of the salts (PPN) and the elastomer with each other.

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The fluorinated elastomers obtained from the compositions of the present invention are utilizable as sealing gaskets, in both static and dynamic conditions, in the motorized, mechanical, naval fields, as protective garments for the contact with aggressive chemical agents, as sheaths which protect electrical cables when exposed to an intense thermal radiation, and in other similar appliances.

The following examples are given only to the purpose of better illustrating the present invention, and are not to be considered as in any way limitative of the invention.

Examples 1—3

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Different vulcanization blends containing some polyhydroxyl vulcanizing agents were prepared. In all blends, the accelerator utilized was the type A1 described hereinbefore.

There was employed the fluorinated elastomer known as Tecnoflon NML (trademark of Montefluos relating to an elastomeric copolymer of vinylidene fluoride with hexafluoropropene in a 4:1 molar ratio, having a Mooney ML viscosity (1+4) at 100°C=55 and a specific gravity at 25°C=1.816 g/cm³).

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Examples 4—8

Different vulcanization blends containing different accelerators described hereinbefore were prepared. In all blends bisphenol AF was used as vulcanizing agent.

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The fluorinated elastomer known in commerce as Tecnoflon NM (a Montefluos trademark relating to an elastomeric copolymer of vinylidene fluoride with hexafluoropropene in a 4:1 molar ratio, having a Mooney ML viscosity (1+4) at 100°C=85 and a specific gravity at 25°C=1.816 g/cm³) was used.

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TABLE 1

	Formulation No.	1	2	3	
5	Tecnoflon NML	parts by weight	100	100	100
10	Maglite® D	" "	5	5	5
15	Ca(OH) ₂ —VE (1)	" "	5	5	5
20	Carbon black MT	" "	30	30	30
25	Bisphenol A	" "	2,3	—	—
30	Bisphenol AF	" "	—	1,8	—
35	Sulphondiphenol	" "	—	—	2,4
40	A ₁	" "	0,6	0,6	0,65
45	Thermo-mechanical characteristics				
50	O.D.R. at 175°C (3)				
55	Minimum torque Inch/lbs.		16	17	15
60	T ₂ minutes (2)		5,2	3,2	5,0
65	T ₅₀ minutes (3)		8,2	5,6	9,8
70	Maximum torque Inch/lbs.		90	115	100
75	Viscosity				
80	Mooney MS at 121°C (4)				
85	minimum		46	40	42
90	minutes for a 10-point increase		45	65	60
95	Vulcanization				
100	in press at 170°C for 10 minutes				
105	in oven at 250°C for 16 hours				
110	Modulus at 100% elong. Kg/cm ² (5)		60	75	65
115	Tensile strength Kg/cm ² (5)		125	170	145
120	Elongation at break % (5)		200	210	150
125	Hardness, IRHD (6)		71	73	73
130	Compression set				
135	O-Rings (φ 25,4×3,53 mm) (7)				
140	at 200°C for 70 hours		29	12	22
145	at 200°C for 168 hours		39	20	40
150	After thermal treatment				
155	at 275°C for 70 hours				
160	%-variation of 100% modulus		+15	0	+22
165	%-variation of tensile strength		-20	-16	-16
170	%-variation of elongation		-17	0	-5
175	variation of hardness, in points		+3	0	+1

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Remarks to Table 1

- (1) Trademark of Sturge Ltd. (Great Britain)
- (2) Time in minutes required to obtain an increase in the minimum value of 2 inch/lbs.
- (3) Time in minutes required to obtain a torque of 50 inch/lbs.
- 5 (3) According to ASTM D 2705-68 T, using an oscillating disk rheometer (biconic disk)
- (4) According to ASTM D 1646-63, using a small size rotor
- (5) According to ASTM D 412-62 T, on 2-mm thick test pieces
- (6) According to ASTM D 1415-68, on 6-mm thick test pieces, reading after 30 seconds
- (7) According to ASTM D395-61, method B.

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TABLE 2

	Formulation No.	4	5	6	7	8
5	Tecnoflon NM parts by weight	100	100	100	100	100
10	Maglite® D "	5	5	5	5	5
15	Ca(OH) ₂ —VE (*) "	5	5	5	5	5
20	Carbon black MT "	25	25	25	25	25
25	Bisphenol AF	1,7	1,7	1,7	1,7	1,7
30	A ₂ "	0,6	—	—	—	—
35	A ₃ "	—	0,65	—	—	—
40	A ₄ "	—	—	0,7	—	—
45	A ₅ "	—	—	—	0,8	—
50	A ₆ "	—	—	—	—	0,7
55	Thermo-mechanical characteristics O.D.R. at 175°C					
60	Minimum torque Inch/lbs.	20	19	18	21	22
65	T ₂ minutss	2,5	2,7	2,9	2,6	3,6
70	T ₅₀ minutes	4,9	5,2	5,3	4,8	6,8
75	Maximum torque Inch/lbs.	110	105	100	115	100
80	Viscosity Mooney MS at 121°C minimum	55	65	60	45	50
85	Vulcanization in press at 170°C for 10 minutes					
90	in oven at 250°C for 16 hours					
95	Modulus at 100% elong. Kg/cm ²	70	65	65	70	75
100	Tensile strength Kg/cm ²	160	165	160	135	140
105	Elongation at break %	210	195	200	190	175
110	Hardness: IRHD	68	70	70	69	68
115	Compression set O-rings (φ 25,4×3,53 mm)					
120	at 200°C for 70 hours	14	12	15	16	16
125	at 200°C for 168 hours	19	21	28	19	21

(*) commercial trademark of Sturge Ltd. (Great Britain)

Ar is preferably phenyl, which is optionally substituted by alkyl C₁₋₄, such as methyl, ethyl, propyl,

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i-propyl, butyl, sec.-butyl, and tert.-butyl, or by chlorine. Ar may contain e.g. 1, 2 or 3 of the above mentioned substituents, the total amount of carbon atoms in the substituents does preferably not exceed 8, most preferably not exceed 4.

5 Claims

1. A vulcanizable fluoroelastomeric composition, comprising
 - A) 100 parts by weight of a copolymer of elastomeric nature based on vinylidene fluoride and of at least another fluorinated monomer,
 - B) 1.5—50 parts by weight of a substance having the property of neutralizing acids, selected from amongst the oxides of divalent metals, the hydroxides of divalent metals and mixtures of such oxides and hydroxides with metal salts of weak acids,
 - C) 0.5—15 parts by weight of a polyhydroxyl and/or polythiol aromatic compound suited to act as a vulcanizing agent for the copolymer, and characterized in that it contains, as a vulcanization accelerator,
- 15 0.05—5 parts by weight of a compound having the structure of bis(triarylphosphin)-iminium salt of general formula:



- 20 wherein Ar is an aryl radical, n=1 or 2, X is a monovalent or divalent anion.
2. The vulcanizable fluoroelastomeric composition according to claim 1, in which X is tetrafluoroborate.
3. The vulcanizable fluoroelastomeric composition according to claim 1, in which X is tetraphenylborate.
- 25 4. Manufactured articles comprising vulcanized fluoroelastomers obtained starting from the compositions of claim 1.

Patentansprüche

- 30 1. Eine vulkanisierbare fluorelastomere Zusammensetzung, welche umfaßt:
 - A) 100 Gew.-Teile eines Copolymers von elastomerer Natur auf der Basis von Vinylidenfluorid und mindestens einem weiteren fluorhaltigen Monomer:
 - B) 1,5 bis 50 Gew.-Teile einer Substanz mit der Eigenschaft, Säuren zu neutralisieren, ausgewählt aus den Oxiden zweiwertiger Metalle, der Hydroxiden zweiwertiger Metalle und Mischungen solcher Oxide und Hydroxide mit Metallsalzen schwacher Säuren;
 - C) 0,5 bis 15 Gew.-Teilen einer aromatischen Polyhydroxyd- und/oder Polythiolverbindung, die als Vulkanisierungsmittel für das Copolymer wirken kann, dadurch gekennzeichnet, daß sie als Vulkanisierungsbeschleuniger 0,05 bis 5 Gew.-Teile einer Verbindung mit der Struktur des Bis(triarylphosphin)-iminiumsalzes der allgemeinen Formel
- 40 $[\text{Ar}_3\text{P}=\text{N}=\text{P Ar}_3]_n^+ \cdot \text{X}^{n-}$

worin Ar ein Arylrest ist, n=1 oder 2 ist, X ein einwertiges oder zweiwertiges Anion ist, enthält.
2. Die vulkanisierbare fluorelastomere Zusammensetzung nach Anspruch 1, in welcher X Tetrafluorborat ist.
3. Die vulkanisierbare fluorelastomere Masse nach Anspruch 1, in welcher X Tetraphenylborat ist.
4. Erzeugnis, welches die vulkanisierten Fluorelastomeren umfaßt, die, ausgehend von den Zusammensetzungen gemäß Anspruch 1, erhalten worden sind.

50 Revendications

1. Une composition vulcanisable fluoroélastomère comprenant:
 - A) 100 parties en poids d'un copolymère de nature élastomère à base de fluorure de vinylidène et d'au moins un autre monomère fluoré;
 - B) 1,5 à 50 parties en poids d'une substance ayant la propriété de neutraliser les acides, choisie parmi les oxydes de métaux divalents, les hydroxydes de métaux divalents et les mélanges de tels oxydes et de tels hydroxydes avec des sels de métaux d'acides faibles;
 - C) 0,5 à 15 parties en poids d'un composé aromatique polyhydroxyle ou polythiol propre à agir comme agent vulcanisant pour le copolymère, et caractérisée en ce qu'elle contient, comme accélérateur de vulcanisation, de 0,05 à 5 parties en poids d'un composé ayant la structure d'un sel de bis(triarylphosphine)iminium de formule générale:
- 60 $[\text{Ar}_3\text{P}=\text{N}=\text{P Ar}_3]_n^+ \cdot \text{X}^{n-}$

65 dans laquelle:

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Ar représente un radical aryle;

n égal 1 ou 2;

X représente un anion monovalent ou divalent.

2. La composition fluorélastomère vulcanisable selon la revendication 1, dans lequel X est un tétrafluoroborate.

3. La composition fluoroélastomère vulcanisable selon la revendication 1, dans laquelle X est un téraphénylborate.

4. Articles manufacturés comprenant des fluoroélastomères vulcanisés obtenus en partant des compositions de la revendication 1.

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